

CLAIMS

1. An electric power assisted steering apparatus for a vehicle, comprising:
- 5 a steering mechanism, which operatively connects a steering wheel to the road wheels of the vehicle;
- an electric motor operatively connected to the steering mechanism;
- a torque sensing means adapted to produce a first output signal indicative of the torque carried by a portion of the steering mechanism;
- 10 a vehicle speed sensing means for producing a second output signal indicative of the speed of the vehicle;
- a signal processing unit adapted to receive the first and second signals and to produce a torque demand signal representative of a torque to be applied to the steering mechanism by the motor; and
- 15 a motor drive stage adapted to provide a drive current to the motor responsive to the torque demand signal,
- in which the apparatus includes torque limiting means, arranged to limit the magnitude of the torque to be applied to the steering mechanism to a maximum of a value that increases in time from a first value to a second
- 20 value at a rate that is dependent on the second signal.
2. The electric power assisted steering apparatus of claim 1 in which the torque limiting means is arranged to limit the magnitude of the torque when the apparatus is powered-up.
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3. The electric power assisted steering apparatus of claim 1 or claim 2 further comprising speed mapping means, arranged to generate from the vehicle speed a torque limit increase signal indicative of the rate at which the torque limit is to increase.

4. The electric power assisted steering apparatus of claim 3 in which the torque limit increase rate for a first vehicle speed is higher than the torque limit increase rate at a second, higher, vehicle speed.

5 5. The electric power assisted steering apparatus of claim 3 or claim 4 in which the speed mapping means determines the torque limit increase rate between the first and second speeds by interpolation.

6. The electric power assisted steering apparatus of any one of claims
10 3 to 5 in which the speed mapping means is arranged to generate, from the torque limit increase signal, the torque limit to be passed to the torque limiting means.

7. The electric power assisted steering apparatus of claim 6 in which
15 the speed mapping means is arranged to calculate the torque limit as increasing linearly at the torque limit increase rate.

8. The electric power assisted steering apparatus of claim 6 in which the torque limit increases non-linearly.

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9. The electric power assisted steering apparatus of claim 8 in which the rate at which the torque limit increases increases with time.

10. The electric power assisted steering apparatus of claim 8 or claim 9
25 in which the speed mapping means includes intermediate value generating means and non-linear mapping means, where the intermediate value increases linearly at the torque limit increase rate and the non-linear mapping means is arranged to map the intermediate value to generate the torque limit using a non-linear map.

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11. The electric power assisted steering apparatus of claim 10 in which the map is defined by at least three points defining the relationship between the intermediate value and the torque limit at those points, and in which successive pairs of points in increasing intermediate value may
5 have an increasing gradient between them.

12. The electric power assisted steering apparatus of any preceding claim further comprising filter means, to filter the measured vehicle speed, the filter means being a low pass filter.

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13. The electric power assisted steering apparatus of any preceding claim further comprising offset means, which take as an input the torque limit and combine the torque limit with an additive offset.

14. The electric power assisted steering apparatus of any preceding claim further comprising cap means, which cap the torque limit to a maximum value.

15. An electric power assisted steering apparatus for a vehicle,
20 comprising:

a steering mechanism, which operatively connects a steering wheel to the road wheels of the vehicle;

an electric motor operatively connected to the steering mechanism;

a torque sensing means adapted to produce a first output signal indicative
25 of the torque carried by a portion of the steering mechanism;

a signal processing unit adapted to receive the first signal and to produce a torque demand signal representative of a torque to be applied to the steering mechanism by the motor; and

a motor drive stage adapted to provide a drive current to the motor
30 responsive to the torque demand signal,

in which the apparatus includes torque limiting means, arranged to limit the magnitude of the torque to be applied to the steering mechanism to a maximum of a value that increases from a first value to a second value at a rate that varies with time.

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16. The electric power assisted steering apparatus of claim 15 in which the torque limiting means is arranged to limit the magnitude of the torque when the apparatus is powered-up.

10 17. The electric power assisted steering apparatus of claim 15 or claim 16 in which rate at which the torque limit increases increases with time.

15 18. The electric power assisted steering apparatus of any one of claims 15 to 17 in which the torque limiting means includes intermediate value generating means and non-linear mapping means, in which the intermediate value generating means is arranged to generate an intermediate value that increases linearly at a torque limit increase rate and the non-linear mapping means is arranged to map the intermediate value to generate the torque limit using a non-linear map.

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19. The electric power assisted steering apparatus of claim 18 in which the map is defined by at least three points defining the relationship between the intermediate value and the torque limit at those points, in which successive pairs of points in increasing intermediate value have an increasing gradient between them.

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20. The electric power assisted steering apparatus of any one of claims 15 to 19 further comprising a vehicle speed sensing means for producing a second output signal indicative of the speed of the vehicle, in which the rate at which the torque limit increases is dependent upon the second output signal.

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21. A method of controlling an electric power assisted steering apparatus for a vehicle having a steering mechanism, comprising:
measuring the torque in a part of the steering apparatus; and
5 calculating a torque demand signal indicative of the torque to be applied to the steering mechanism by an electric motor;
in which the magnitude of the torque to be applied to the steering system is limited to a maximum value, which depends on the speed of the vehicle.
- 10 22. The method of claim 21 in which the magnitude of the torque is limited when the apparatus is powered-up.
- 15 23. The method of claim 21 or claim 22 further including the step of generating a torque limit increase signal from the vehicle speed indicative of the rate at which the torque limit is to increase.
- 20 24. The method of claim 23 in which the torque limit increase rate for a first vehicle speed may be higher than the torque limit increase rate at a second, higher, vehicle speed.
- 25 25. The method of claim 23 or claim 24 in the torque limit is calculated as increasing linearly at the torque limit increase rate.
26. The method of claim 23 or claim 24 in which the torque limit increases non-linearly.
27. The method of claim 26 in which the rate at which the torque limit increases increases with time.

28. The method of claim 26 or claim 27 further including the steps of generating an intermediate value, where the intermediate value increases linearly at the torque limit increase rate, in which the intermediate value is mapped using a non-linear map to generate the torque limit.

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29. The method of claim 28 in which the map is defined by at least three points defining the relationship between the intermediate value and the torque limit at those points, in which successive pairs of points in increasing intermediate value have an increasing gradient between them.

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30. The method of any one of claims 21 to 29 further including the step of filtering the measured vehicle speed with a low pass filter.

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31. The method of any one of claims 21 to 30 in which the method includes the step of combining the torque limit with an additive offset.

32. The method of any one of claims 21 to 31 in which the method includes the step of capping the torque limit to a maximum value.

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33. A method of controlling an electric power assisted steering apparatus for a vehicle having a steering mechanism, comprising:

measuring the torque in a part of the steering apparatus; and
calculating a torque demand signal indicative of the torque to be applied to the steering mechanism by an electric motor;

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in which the magnitude of the torque to be applied to the steering system is limited to a maximum value, which increases at a rate that varies with time.

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34. The method of claim 33 in which the magnitude of the torque is limited when the apparatus is powered-up.

35. The method of claim 33 or claim 34 in which the rate at which the torque limit increases increases with time.

36. The method of any one of claims 33 to 35 in which the method
5 includes the steps of generating an intermediate value that increases linearly at a torque limit increase rate, and in which the intermediate value is mapped using a non-linear map to generate the torque limit.

37. The method of claim 36 in which the map is defined by at least
10 three points defining the relationship between the intermediate value and the torque limit at those points, and in which successive pairs of points in increasing intermediate value may have an increasing gradient between them.

15 38. The method of any one of claims 33 to 38 further comprising the step of determining the vehicle speed and in which the rate at which the torque limit increases is dependent upon the vehicle speed.

20 39. A data carrier carrying a program which, when loaded onto a processor of a suitable apparatus, causes the apparatus to carry out the method of any one of claims 21 to 38.